MINING
Project Fact Sheet

A Motor Challenge Technical Case Study

Optimized Pump Systems Save Coal Preparation Plant Money and Energy

Benefits

- Saved $5,231 in annual energy cost savings
- Saved 87,184 kWh of electricity
- Decreased energy consumption by 15%
- Payback of 3.3 years
- Lowered maintenance costs

Project Summary

Peabody Holding Company completed a project to improve the performance of a coal slurry pumping system at its Randolph Coal Preparation plant. Changes to the coal washing process resulted in cyclone pump systems that were larger than necessary to meet system requirements. This case study describes the performance optimization conducted by the Motor Challenge Showcase Demonstration team on one of the six classifying cyclone pumps. Using a systematic approach, three energy-saving opportunities were identified involving the motor, belt drive, and pump components of the pumping system. The modifications saved 87,184 kWh of electricity, equivalent to $5,231 in annual energy cost savings, and overall energy consumption of the pumping system decreased by approximately 15 percent.

Company Background

Peabody Holding Company, Inc., generates more than $2 billion in annual revenues by providing policy management and strategic planning to the Peabody Group, comprised of 50 coal mining, marketing, and related corporations in the United States and Australia. Together, these corporations operate 29 mines and own or operate roughly 12 billion tons of steam and metallurgical coal reserves throughout the world.

Coal Slurry Pumping System

Project Overview

The Randolph Coal preparation plant processes and cleans bituminous coal supplied by Peabody's Marissa Underground Mine, near Baldwin, Illinois. The coal is removed by using a coal extraction technique involving rotary drums that shear coal, shale, and fire clay from the coal seam. After removing large non-coal fragments, water is added to the raw coal to produce a 12 percent coal slurry to separate the remaining shale, fire clay, and other particles from the coal. Six 200-hp classifying cyclone pumps transport the coal slurry from a common sump to the two classifying cyclones that separate the slurry into two types. The slurry containing smaller mesh particles is discarded while the slurry containing larger mesh particles is dewatered and discharged as clean coal.

The Randolph preparation plant was selected for process optimization due to numerous changes to the coal washing process. The six pumps used to transport slurry to the cyclones exceeded system process requirements, which can lead to inefficient operation. Alternatives to increase the energy efficiency of the pumping system were identified and evaluated. This project focuses on one (Number 5) of the six cyclone classifying pumps which is representative of all six pumps. Only one pump was selected so that multiple system optimization techniques could be explored without excessive costs.

Project Team

In addition to the host company, the Showcase Demonstration project team involved several Motor Challenge partners including U.S. Electrical Motors, GIW Industries, Inc., and the local electric utility. U.S. Electrical Motors and GIW Industries, Inc., supplied the equipment and performed system modifications throughout the project's implementation period. Electric metering of the pumping system for the base case and alternative scenarios was provided by the local electric utility. Other mechanical engineering services and hardware provided to the host company were performed by The Benham Group.

Project Implementation — The Systems Approach

Project engineers realized the current system was oversized, not operating at its best efficiency point, and had not received proper maintenance over the years. To determine potential improvement opportunities, the engineers applied the systems approach—a way to increase the efficiency of an electric motor system by shifting focus away from individual elements and functions to total system performance. By utilizing the systems approach, Peabody Holding was able to determine an overall strategy for optimizing the No. 5 cyclone pump. The strategy involved all three main elements of the pumping system: the pump casing and impeller, the motor, and the V-belt drive.

The Old System

Under normal conditions, the pump runs at constant volume and operates approximately 16 hours a day for 250 days a year. The original pump system utilized a 10" x 10" casing equipped with a 32" diameter impeller designed to pump an estimated 4,650 gallons-per-minute (gpm) at a head of 114 feet. The pump was driven by a 200-hp, 1,750-rpm standard efficiency motor through a conventional V-belt drive. The team determined that the original system exceeded process requirements. Overall “wire-to-water” system efficiency was rated at less than 59 percent. Average volume flow was estimated at an average of 3,612 gpm at a head of 107 feet, less than the pumps most efficient operating point. Overall energy consumption was estimated at 513,766 kWh of electricity per year.

Alternatives Considered

One option considered involved slowing down the pump to reduce speed and lower energy consumption levels; however, initial calculations showed little energy savings from performing this task. Engineers also considered staging the six pumps, but this proved impractical. Another option was replacing the V-belt drive with a newer “toothed-belt” drive, rated at efficiency levels of 98 percent. After several tests, it was determined that the toothed-belt drive did not significantly increase the efficiency of the pump system. In addition, toothed-belt drives are less tolerant of contamination and are significantly more noisy than V-belt drives. The optimal solution proved to be a combination of system modifications, which include replacing the pump’s motor with a more efficient motor, downsizing the pump, and re-tensioning the V-belt.

The New System

The modified system uses a smaller pump with an 8" x 10" casing and a 32" diameter impeller with an output that more accurately matches system flow requirements. The original motor was replaced with a new premium efficiency 200-hp, 1800-rpm motor rated at 96.5 percent efficiency. At the time of replacement, the team also determined that the motor slide base should be replaced as a result of extreme corrosion. Maintenance of the V-belt drive, to prevent corrosion and set the proper tension, was also performed.

Why Oversized Pumps Decrease Performance

Many design engineers purposely oversize pumps, taking into account factors such as safety margins, potential corrosion build up, and the possibility of increased flow requirements in the future. This often leads to throttling the system with a control valve because the pump delivers more flow than the system requires. The result is a pump that is not running at its Best Efficiency Point (BEP). Possible consequences of this include noise and vibration, excessive bearing loads, cavitation, and excessive power consumption. Pumps that are being throttled and are operating far off their BEP should be considered for retrofit. Possible changes to consider are retrofitting with a smaller pump, using an impeller with a smaller diameter, or slowing the operating speed of the pump. In many cases, these changes will not only save energy, but also increase the reliability of the system.

Results

Overall energy efficiency as a result of the motor replacement, V-belt drive tensioning, and pump modifications increased by 14.9 percentage points from 58.7 percent to 73.6 percent efficiency.

Annual Energy and Cost Savings

Implementation Costs	$15,693
Energy Cost Savings	$ 5,231
Payback (Years)	3.3
Demand Savings (kWh)	21.8
Energy Savings (kWh)	87,184

Total Annual Emissions Reductions

CO_2	182,633 lbs
Carbon Equivalent	49,900 lbs
SO_2	5,115 lbs
NO_x	1,090 lbs
PM	42.4lbs
CO	21 lbs
Non-Methane Hydrocarbons	2.5 lbs

When performed on each of the remaining five pumps, the performance optimization will result in an estimated 523,000 kWh in savings and $31,000 in annual cost savings.

Lessons Learned

Lessons learned include: (1) To ensure that pump systems are performing at optimal levels, the volume flow rate should be calculated to determine the appropriate sized pump, rather than automatically replacing old pump casings with new pump casings of the same size when they wear out. By not only replacing the pump casing but by changing the size of the pump casing to more accurately match the required flow rate, operating costs can be reduced significantly; (2) High performance belt drives can increase energy efficiency and reduce costs; however, routine maintenance of the V-belt drive rather than replacement of the drive with high performance belt drives may yield higher savings; and (3) After a pump casing and impeller are replaced with smaller ones, the system requires less motor power than was needed prior to system modifications.

Industry of the Future—Mining

In mid-1998, the National Mining Association reached an agreement with the U.S. Department of Energy's Industries of the Future Program to join in creating research and development partnerships to develop and deploy new technologies that will improve environmental performance and enable the industry to meet increased global competition. The mining industry supplies the minerals and coal essential to the infrastructure of virtually the entire U.S. economy: glass, ceramics, metals, and cement for buildings, bridges, roads, and equipment, and coal or uranium to generate more than 70% of the nation's electricity.

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MOTOR CHALLENGE

Motor Challenge, administered by the Office of Industrial Technologies, is a voluntary partnership program with U.S. industry to promote the use of energy-efficient electric motor systems. Thousands of industrial partners have joined Motor Challenge and are improving their competitiveness and efficiency and, in turn, the Nation's.

Motor Challenge assists the mining industry and other OIT Industries of the Future by identifying near-term gains in energy efficiency these industries can achieve by adopting existing technologies.

Project Partners

Peabody Holding Company
Marissa, IL

U.S. Electrical Motors
St. Louis, MO

GIW Industries, Inc.
Grovetown, GA

The Benham Group
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